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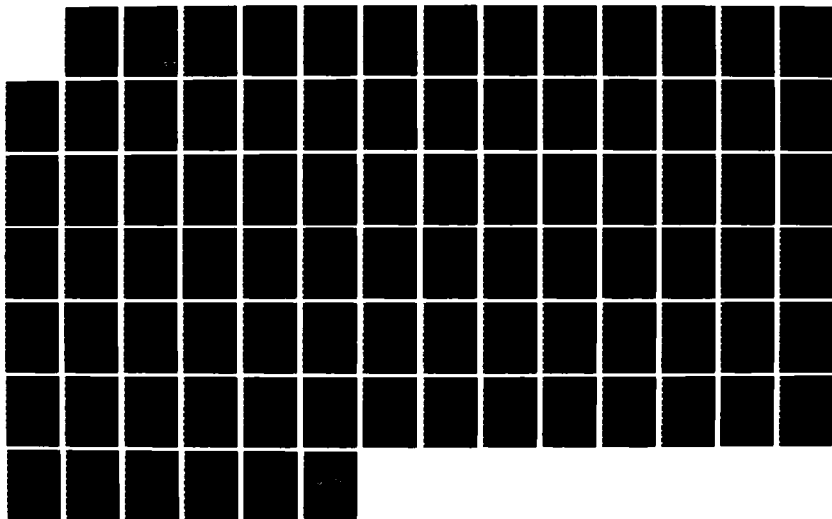
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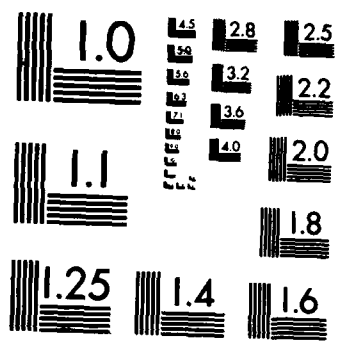
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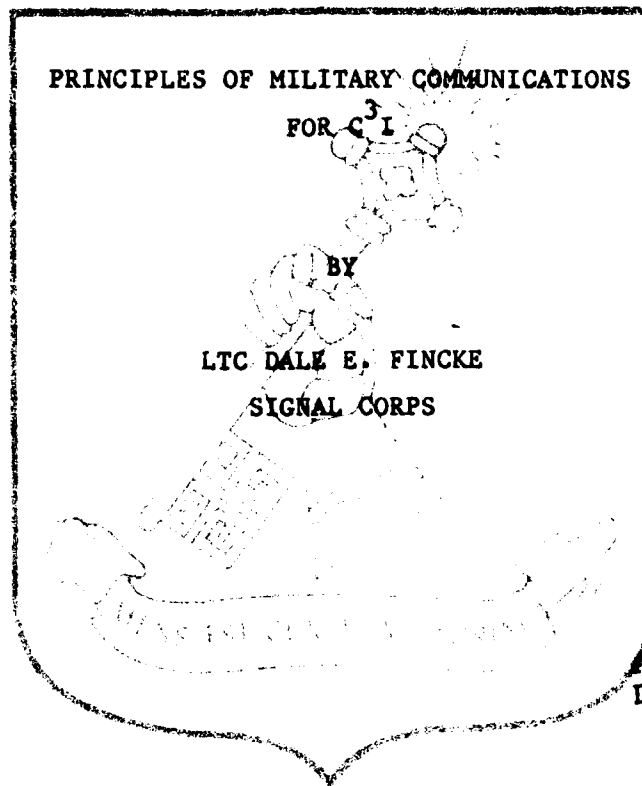




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Finally, a chapter on implications for system design describes a conceptual military communications system founded on the principles developed and discussed in this paper.

PRINCIPLES OF MILITARY COMMUNICATIONS
FOR C³I

BY

LTC DALE E. FINCKE
SIGNAL CORPS

ADVANCED OPERATIONAL STUDIES FELLOWSHIP PROGRAM
SCHOOL OF ADVANCED MILITARY STUDIES
U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE
FORT LEAVENWORTH, KANSAS

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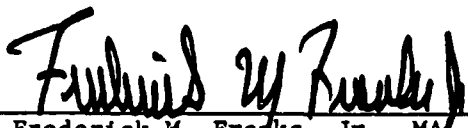
Name of Fellow: LTC Dale E. Fincke

Title of Research Paper: Principles of Military Communications For C³I

Approved By:


(Colonel Richard H. Sinnreich, MA)

Director, School of Advanced
Military Studies


(BG Frederick M. Franks, Jr., MA, M.Phil.)

Deputy Commandant, U.S. Army
Command and General Staff
College


(Lieutenant General Robert W. RisCassi, MA)

Commander, Combined Arms
Center



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Finally, a chapter on implications for system design describes a conceptual military communications system founded on the principles developed and discussed in this paper.

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CHAPTER I

INTRODUCTION

The subject of Command, Control, Communications and Intelligence (C³I) information acquisition and transfer has evolved as a keystone element in the U.S. Army's capability to synchronize combat effects at the desired times and places. The result has been a gradual shift in C³I philosophy toward a central role in how the U.S. Army will fight, as envisioned in Field Manual 100-5, OPERATIONS, to exploit tactical and operational level warfighting potential. This evolution has been accompanied by numerous efforts to use available technology and modifications of existing equipment, to grapple with some exceedingly complex issues.

The thesis presented in this paper is that there is a coherent group of previously uncoded basic concepts--military communications principles--and that their comprehension should provide a theoretical linkage in support of the tenets of US AirLand Battle doctrine, as well as provide a stable foundation in the continuing development of the C³I process.

This paper is a departure from other attempts to deal with this subject in several ways of particular significance to the U.S. Army.

This paper focuses on the development of theory for military command and control communications (C³) and embraces and supports the tactical and operational concepts of AirLand Battle described in Field Manual 100-5, OPERATIONS (May, 1986). The theoretical principles proposed here recognize the efficacy of the combined arms concept at the tactical level, and that the sequencing of tactical activities and events in battle will almost invariably be a joint affair involving air, land, and possibly sea forces at the operational level. Also, because of the interdependent nature of today's world, wars of the future will probably be fought by coalitions. Therefore, these military C³ principles will provide unifying concepts to enable the flow of requisite information and directions among all the elements of the force regardless of function, service, or nationality.

A single aspect of the C³I information acquisition and transfer equation is addressed--communications. The rationale for addressing the operational principles of the communications element of C³I synergism is that communications ties together aggregate C³I. This is particularly true in the coordination of warfighting and sustaining potential, the decentralization of command functions, and the synchronization of effects from distant activities. Although FM 100-5 actively promotes the aggressive exploitation of opportunities in the absence of communications based on intimate knowledge of the commander's intent, the dynamic nature and tempo of the modern battle dictate that should command and control fail for an extended period of time, almost nothing else matters. Adequate communications to

facilitate the rapid and timely transfer of information and direction to combat and support forces is a prerequisite for effective Command and Control. At the operational level of warfighting, with the high probability of joint and combined operations, the necessity for adequate communication among all the forces is a requirement for mission accomplishment. Although this paper addresses the communication aspects of C³I, the principles suggested are also implicit in each individual element and in the aggregate C³I process.

In the specific area of Command, Control, Communications and Intelligence (C³I), we are currently attempting to solve specific contemporary communications problems without a foundation of communication principles consistent with AirLand Battle doctrine. This paper is not concerned with these specific solutions; but without some agreed foundations, such solutions are likely to differ among and within services. This will lead to restricted, untimely information flow and battlefield inflexibility. We need to develop a theoretical base consistent with our doctrine. The proposed principles developed in this paper are initial ideas that seem to provide the most significant basis for the mutual understanding of how to think about communications. Such a basis is the more essential given the increasing complexity and accelerating pace of warfare, and as we depend more and more on technology. These principles of communications should form the qualitative foundation against which current and future communication methods, architectures, and equipments should be assessed.

The value of the theoretical principles postulated in this paper depends on the extent of their inter- and intra-service application. This elaboration of proposed communication principles seeks to demonstrate development of an appreciation for: the utility of the fundamental principles; their broad applicability as combat multipliers; and their adaptability to a wide variety of means and combinations of means. Finally it seeks to stimulate further thought on this subject. It is hoped that this exposition will contribute to the development of principles providing correlation with the tenets of AirLand Battle and which can guide specific programs.

CHAPTER II

SETTING THE STAGE

In order to make the development of the theoretical principles of military Command and Control Communications (C³) a rational process, it is first necessary to establish a common understanding of the contemporary combat environment, the objective of command and control and the role which communications plays in the collective C³I synergism.

Contemporary assumptions concerning the evolving nature of warfighting envision an enemy who expects to sustain rapid movements and who will use every weapon at his disposal to attain his goal. The tactical and operational battlefield may range from a low-intensity conflict environment, one in which military force may be the least desirable alternative, to a mid-to-high intensity conflict environment. This latter environment is most likely to be characterized by extended, non-linear frontages and depth for which the commanders at all levels are responsible. Other characteristics of this battlefield will be: 1) localized massive troop concentrations and destructive fires; 2) changing direction of attack, pressing points of weakened resistance, and following the line of least resistance; 3) a continual flow of enemy forces from the rear endeavoring to exploit success by rolling up the flanks of any gap; 4) attacks and counterattacks without the benefit of flank coordination with adjacent friendly units; 5) sharp changes in the tactical and operational situation; 6) the use of diverse, complex, lethal and long range modern combat weaponry; 7) increased sensor

capabilities; 8) increased dispersion and mobility; 9) increased probability of a nuclear, chemical, biological, or combination environment; 10) significant increases in the availability of information and the ability to intercept, interrupt, jam or destroy communications; 11) increased complexity of logistics support to sustain combat; 12) increased use and vulnerability of the air space above the battlefield; 13) convergence of the distinction between close and rear operations; and, 14) the increased probability of joint and coalition warfare.

Against this backdrop, AirLand Battle Doctrine describes the U.S. Army's understanding of the nature, theory, and practice of war; prescribes the general principles and methods by which Army units fight in concert with other services and allies; and applies today, worldwide, across the full spectrum of conflict at the tactical and operational level.¹

o AirLand Battle Doctrine is based on the philosophy of securing and retaining the initiative and operating aggressively to defeat enemy forces.²

o To execute this maneuver oriented offensive warfare doctrine successfully, operations must be conducted in accordance with the four fundamental tenets of AirLand Battle:

Initiative - The setting or changing the terms of battle by action.

Agility - The ability of a force to act faster than the enemy.

Depth - The extension of operations in time, space and resources.

Synchronization - The arrangement of battlefield activities in time, space, and purpose to produce maximum relative combat power at the decisive point.³

The tempo of the combat environment and the doctrinal philosophy prescribed by FM 100-5 place particularly high demands on the commander, his subordinate commanders and their Command, Control, Communications and Intelligence (C³I) apparatus. FM 100-5 states: "the only purpose of command and control is to implement the commander's will in pursuit of the unit's objective."⁴

For the Commander's will to be relevant to the actual situation on the battlefield the aggregate C³I process must continually acquire critical information on the situation, disseminate mission information in a timely and succinct manner, coordinate supporting units, synchronize widely dispersed supporting activities' effects, and implement the Commander's intent firmly yet flexibly. The idea of firm but flexible implementation of the Commander's intent may seem a contradiction in terms. As indicated earlier, warfare is expected to be fought in a dynamic environment where constant change, uncertainty, and the unexpected will be the norm. In such an environment the development of the engagement, battle, or campaign may not happen exactly according to the assumptions made and the execution ordered.

The Commander, his staff, subordinate and supporting commanders, and their aggregate C³I capability must effect timely coordination, sequencing and synchronization of their battle plans and activities in accordance with the will and intent of the senior commander. If the situation is significantly altered, new decisions must be expeditiously formed based on the revised situation. The decision must then be disseminated and coordinated, and the effects of supporting activities synchronized to respond to the revised circumstances. This is equally applicable at the tactical and operational levels of war and especially true in joint and combined operations.

In modern warfare the commander attempts to organize the chaos of combat and obtain a realistic picture of the battlefield. The challenge is to seize and retain the initiative with all available means, faster than the opposing force, in order to maximize relative combat power by concentrating rapidly and striking unexpectedly. To do this there must be the right communications capability to pull together and disseminate a wide variety of information.

To ensure manageable communications, basic concepts must be both rigorous and clear. The five operational principles presented in this paper provide a starting point for the development of military communication theory in support of current operational doctrine. They do not pretend to solve all the problems; they merely provide insights and guidance for those dealing with specific contemporary issues. In the application of the operational principles to contemporary issues, compromises between conflicting solutions may be

required--decisions may have to be made as to which principles to emphasize and to what degree. Lack of understanding of agreed-to theoretical constructs can lead to decisions based on habit, whim, obvious convenience, pride of authorship, technological promises, emotion, and/or economics. The purpose of the operational principles of military communications is to minimize these influences and to ensure systematic analysis based on theory.

The development of operational principles for the communications element of the C³I process is an attempt to promote command and control flexibility by developing "how to think" ideas about communications in support of "how we think" ideas about warfighting. These interwoven principles have many corollaries and offer unlimited opportunity for imaginative application to changing conditions.

CHAPTER III

PRINCIPLE OF CONTINUITY

The principle of "CONTINUITY" should be considered the first and most important principle of communications for C³I. Continuity stresses the uninterrupted availability of communication paths, which permits C³I functions to be adequately performed. In any existing combat environment, at any place or places on the battlefield it is necessary to provide the commander (and his staff) correct information which enables him to exert his will on combat operations, to mass available resources, and to synchronize dispersed supporting activities. History provides two excellent examples of the importance of continuity of communications-the attempt to exploit initial success of the Schlieffen plan in World War I and Rommel's attempt to strike deep against the British Eighth Army in the concluding days of Operation Crusader in World War II.

Germany went to war in 1914 with seven armies in the west. On the right flank four armies were to carry out Count Alfred von Schlieffen's plan of pivoting on Metz, wheeling through Belgium and France. The remaining four armies had the task of making a short advance followed by an elastic defense on a wide front. The main burden on the right flank fell to the powerful right wing of von Kluck's First Army in the north, where it bore down past Mons toward La Cateau and Paris. Von Bulow's Second Army, also a part of the right wing but south of the First Army, was to follow an axis of advance south of Liege to La Cateau and on south to the east of

Paris. In August, when the Fifth French Army stood its ground behind the river Serre and the British Expeditionary Force continued its withdrawal, a gap opened between the two German Armies in the north. General Lieutenant von Richthofen's I Cavalry Corps was directed by radio into the gap and told to turn east to seize ground between Soissons and Vauxaillon, thus cutting off the French Fifth Army's retreat. Because of poor communications security the French intercepted this order almost as quickly as Richthofen (most German Communications were either in the clear or in code and the French had broken the German code within forty-eight hours of the outbreak of the war). A race ensued as the French dispatched infantry by rail and cavalry by road to block the German thrust before it reached its objective. German progress was monitored by radio reports from leading troops. But the Germans were advancing too fast. There was little opposition and as they got deeper into the gap they complained about logistics. A radio message (duly monitored by the French) requested supplies be sent to Noyon, which was at the starting point of their sweep. The whole I German Cavalry Corps safely reached the area north of Soissons, well into the French rear, but was then pulled back. Growing pressure on his right flank caused Von Kluck to take hasty defensive measures; the French poured into the gap so that the cavalry was compelled to dismount in order to fight. Von Bulow, in turn, was also threatened and so the opportunity could not be exploited. Richthofen, a commander who understood mobility, had actually created the opportunity dreamed of by all cavalrymen. He had so outpaced the enemy that they were unable to devise defensive

measures fast enough to bar his way, but since he had allowed himself to become divorced from his communications, his favorable position was unknown to those above him.⁵

The Second World War also provides an excellent example of the importance of continuity of communications. In the concluding days of the British offensive Operation Crusader in North Africa, Rommel sought to exploit previous limited successes with a deep thrust with all his mobile forces to and over the frontier--into the rear area of the British Eighth Army. Rommel was striking at the mind of the opposing commander, as well as against the rear of opposing forces and their supplies. On the previous day, 23 November 1941, following the disastrous British outcome of the armored phase of the battle, LTG Sir Alan Cunningham had thoughts of retreating back over the frontier, and had only been stopped by the arrival of his superior, Sir Claude Auchinleck--who flew up from Cairo and insisted on a continuation of the struggle. Rommel's dash for the frontier, however, caused a stampede among Allied forces in his path, and naturally produced still greater alarm at British Eighth Army Headquarters. Rommel set off on 24 November 1941 leading the 21st Panzer Division. He ordered the 15th Panzer Division to follow with the promise that the Italian Mobile Corps (Ariete armored and Trieste motor divisions) would support the Panzer division. The intention was to close the ring around British forces. After five hours, Rommel reached the frontier at Bir Sheferzen--covering sixty miles in five hours. On arrival, he sent a battle group through the frontier wire on a northeastward drive to the Halfaya Pass. This force was to

threaten the Eighth Army's eastward route of retreat and supply, while extending the threat into the British rear. Eventually Rommel turned back, but was stranded in the desert for over twelve hours due to engine trouble, and was without communications. Upon his return, Rommel found that the 15th Panzer Division had not yet arrived on the frontier. Also, the Ariete Division had come to a halt at an early stage of its follow up advance--on sighting the 1st South African Brigade in position across its path. The transport columns bringing up fuel and supplies had also failed to arrive. These delays hindered and diminished the development of Rommel's intent. He could not carry out his plan of sending a battle group eastward to Habata, the British railhead, to block both the routes leading down from the steep inland escarpments and the main inland route to Egypt along its crest. He also had to abandon his idea of sending another battle-group southward to the Jarabub Oasis, along the track past Fort Maddalena, where the British Eighth Army's advance headquarters lay. The Germans were suffering from intercommunication troubles. The loss of wireless links was devastating to their operations. Their success depended on quick and coordinated action to develop the threat to the British rear. The best thing the British could do was to stand firm in their frontier positions while the British 13th Corps continued its push on westward to link up with the Tobruk force in a double threat to Rommel's rear. As a result of this threat a succession of signals from Panzer Group HQ, located at El Adem, called for the return of the Panzer Division to relieve the pressure. These disturbing calls from the rear, combined with wireless

breakdowns and fuel shortages in the forward area upset the continuation of Rommel's counterstroke. Rommel was also dismayed to find that, after ordering the quick clearance of the Sollum front by a simultaneous attack with the 15th Panzer Division from the northeast and the 21st Panzer Division on the other side, the 15th had instead moved back to Bardia to replenish fuel and ammunition. It was just returning to the battlefield, while the 21st had withdrawn from Halfaya on a misinterpreted order and was also on its way back to replenish at Bardia. Since no action developed that day, that evening Rommel reluctantly decided to let the 21st Panzer Division continue its journey to Tobruk. The following day he ordered the 15th to follow. This was the finish of a counterstroke that had opened with such great promise.⁶

As the two examples show, continuity of communication directly affected the ability of the commanders to exercise initiative, synchronize effects, achieve agility with their forces and exploit success. The principle of CONTINUITY of communication has risen to contemporary prominence for several reasons: the increased maneuver tempo and depth of modern combat operations; development and fielding of more complex and lethal weapons and information systems; the inherent necessity for mobility and dispersion of command post functions as well as combat and sustainment forces; and the increased ability of the enemy to disrupt communications systems.

In classical theory, analysis begins with the distinction between ends and means. An end is the reason for which something is done, when acting deliberately--as distinct from acting instinctively,

impulsively or irrationally. A means is that which is done or used in order to achieve an end. In this instance, continuity of communications is the desired end; therefore it is necessary to determine the means by which the end is achieved. Unfortunately contemporary C³I systems have come to confuse the volume of information transmitted with the effectiveness and reliability of the system in question. However, all information available is neither required nor desired. In short, continuity of communications-- flawless transmissions of information critical to the commander-- is much more important than volume to the continuity of command and control. The means by which such continuity of communications is attained consist of the application of the qualitative subordinate elements of: survivability, reliability, redundancy, and self-repairability.

* * * * *

Survivability is the capability of the communications to sustain combat loss or degradation and continue to provide requisite information flow and direction among the commander, his staff and all other forces involved. How survivable a system must be depends on how long the commander can afford to go without correct situation orientation, without disseminating direction, without appropriate coordination, and without synchronizing combat effects at the desired times and places.

Design of the communication system must ensure that at least one means always exists among the required users and that the system will automatically find it. The system must be Electro-Magnetic Pulse (EMP) hardened, capable of self-contained operation in a hostile NBC and EW environment, and offer good protection against enemy acquisition and the various types of jamming expected to be encountered on the battlefield.

Since there will always be combat losses and degradation, the key questions which must be answered are whether communications can be made survivable at an affordable cost and with what resultant C³I capability.

* * * * *

Another important subordinate element of CONTINUITY of communications is reliability. The effectiveness and quality of the entire C³I process depends on the reliability of the communication means and the consistent acquisition and exchange of information and direction. Reliability should not be confused with the ability of commanders to deal with uncertainty and to exercise initiative in the absence of communications. On the other hand, competence in decision making depends largely on the quality and completeness of critical information used. Decisions made with insufficient information can be dangerous because they can lead to arbitrariness. Deprived of correct information and unable to impose his will, the commander has little chance of achieving full combat potential where and when

necessary. The key is the reliability of communications to support the commander and his C³I process. The contemporary combat environment is different from that of previous conflicts because of the significant increase in numbers and complexities of modern combat and support systems and the decrease in time available to acquire, decide, disseminate, coordinate, and synchronize. The qualitative criteria for reliability of communications are high probabilities that the communication means will 1) be available to the commander and his staff, 2) support the timely acquisition and transfer of critical C³I information, and 3) not impede the commander from imposing his will on the situation. These must be accomplished within the required time constraints and under the expected operating conditions. The communications means should ensure that the time necessary to transfer information and direction, without sacrificing security and survivability, is as short as possible. This is necessary to provide maximum time for decisions, preparation for execution, and exercise of initiative and surprise by striking before the enemy can react.

A final caution on reliability of communications: reliability as defined by engineers for components of a system does not always translate directly into combat effectiveness for the commander. The total communications means must be evaluated against combat effectiveness and usefulness to the commander and his total C³I requirement.

* * * * *

Communications systems reliability can be significantly improved through Redundancy, the third subordinate element of the principle of CONTINUITY. In general, the properties and structure of the communication system must reflect the overall requirements for which it was intended. For a commander and his staff to entrust command and control responsibilities to a communications system, they must have confidence in the availability of critical information when and where they need it. They must also have the capability for timely dissemination of direction and coordination. The communications system must be convenient to use and guarantee an expected grade of service under all combat conditions. A redundant communications system directly supports the principle of CONTINUITY by providing critical information availability continually throughout the battle area. This information must be processed by intelligent source terminals at points of use, whether grouped or geographically dispersed. The system should permit an interactive conversational exchange of C³I information. It should permit all sources to be interconnected, however heterogenous and regardless of their internal designs, and to share and exchange information. It should also provide decentralized capability for real time information re-routing. Decentralization of capability and control ensures that the failure of any single communication means will disrupt only that single path. Related information elements, even though stored at multiple source terminals and transmitted by multiple means must be

able to be updated as changes occur and acted upon by one or more user terminals as required to accomplish the C³I mission. A redundant communication system also supports principle of SECURITY by promoting indeterminacy of communications. Thus, the qualitative criteria for redundancy of communications are the abilities of source terminals for different functions and echelons to 1) exchange critical information, 2) provide multiple source terminals or intelligent devices access to the same information transfer network, 3) make the communications system transparent to the source (e.g., user), and 4) to provide automatic, real-time re-routing and reconstitution/reorganization within the network. Such a system will optimize C³I capability throughout the battle area. The entire system doesn't have to be redundant, only the number of paths necessary to ensure the required degree of availability under identified conditions.

Unfortunately such a redundant communications system presents some unique communications control problems and thus does not mesh with current centralized methodologies and procedures. The control problems are similar to those associated with the implementation of distributed data base systems: many decision makers each having partial information on the total state of communications and its sources (e.g., commanders, staffs, forces, weaponry, etc). Therefore, centralized decision mechanisms which depend on real time knowledge of the state of the entire system are not possible. Instead, control must be decentralized.

Normally when discussing control, perfection is the goal. Although perfection might be desirable, military systems for C³I require performance to be maintained consistently (e.g., principle of CONTINUITY) and the problem of redundant communications is so complex, battle so dynamic, that we may have to settle for less than perfect but feasible decentralized control.

* * * * *

Continuity of communications can be significantly improved through self-repairability. Self-repairability means the fault tolerance ability of the system to detect, diagnose, contain and repair its own failures. The qualitative criterion for such self-repairability is how automatic it is. This requires that the communication means are partitioned in such a way that any component can diagnose itself and its subordinate parts. It also implies that, once the damage is isolated to a particular function or means, that element is replaced by an identical means which has been held in reserve. It requires that the communication means be capable of changing its control functions and re-routing using the remaining non-damaged routes and functions. This suggests that critical control functions must be decentralized so they can vary as new users and requirements are added to the communication system--a complex requirement. Adding to this complexity is the need for a compilation of the options and available routes to be maintained in real time, so that the system can reconfigure continually as the situation

dictates. Finally, complete and concise information related to the failure or damage and the maintenance procedures required must automatically be communicated to those responsible for operation and maintenance.

CHAPTER IV

PRINCIPLE OF HOMOGENEITY

The second principle of communications for C³I is "HOMOGENEITY." Homogeneity of communications is achieved by selecting uniform means and methods to achieve integrated C³I information acquisition and transfer. Application of this principle assures the commander the capability to synchronize direction of combined arms, and support units of the other services and allies at the tactical and operational levels into efficient teams of land, air, sea, and space elements.

"Early in World War II, the Germans taught the British Army an important tactical lesson in the coordinated use of armor and close air support, backed by motorized artillery and infantry."⁷

The secret to German success was homogeneity of signal communications, primarily radio.⁸ In the United States Army, on the other hand, the various arms (i.e., Armor, Infantry, Field Artillery, Cavalry, and the Air Corps) used different radios operating in different frequency bands as well as different modulation techniques (e.g., AM or FM) which made combined arms command and control below battalion level very difficult.⁹

"In the Ardennes the problem of maintaining control over heterogeneous formations in the St. Vith-Vielsalm area, thereby giving tactical unity to the defense was very difficult. Under sustained German pressure a wholly satisfactory solution never was achieved. The piecemeal employment of lower units, made unavoidable by the pace of events, resulted in convoluted methods of communications. A tank company, for example might have to report by radio to its own

battalion headquarters, some distance away, which then relayed the message on other channels until it reached the infantry battalion to which the tank company was attached. The homogeneity of the battalion, in American practice the basic tactical unit, largely ceased to exist, nor did time and the enemy ever permit any substantial regrouping to restore these units."¹⁰

A more contemporary example is provided by the Armed Forces Journal Extra, October 1985, quoting Senator Sam Nunn concerning Defense Reform using the recent Grenada operations as an example.

". . .it is sobering to look at how much went wrong and at how many failures of coordination and communications there were. . . . We have all enjoyed the story of the Army officer who used his AT&T calling card to phone his office in North Carolina in an effort to coordinate Navy fire support for his position--because the Army units on the ground could not talk to the Navy ships who were supposed to be providing fire support. . . . Their radios were incompatible. One officer from the 82d Airborne Division went to the flagship, the Guam, and borrowed a Marine radio. But that still did not work because he did not know the Navy codes and procedures. Moreover, the Marine and Army units on the ground were not under a unified (e.g. land force) commander. . . . This decreased their effectiveness and increased the danger to each force where they operated in proximity. In summary, the invasion was plagued by the forces' inability to communicate, a problem caused by the services continued practice of buying radios which are not compatible. . . . We have been trying for years to get compatible equipment so we can communicate with our allies, and I would venture to say . . . we would have a mammoth problem in communicating with our Allies. But how in the world do we expect to solve that problem between different countries, different languages, if our Navy here in this country cannot even talk to our Army and vice versa?"¹¹

The preceding examples show how the concept of HOMOGENEITY of communications affects the ability of the commander and his forces to achieve unity of effort. They suggest that homogeneity is vital to the AirLand Battle tenets of synchronization, depth, and agility. With increasingly higher technology being designed into modern weapons, intelligence, and control systems, the concept of HOMOGENEITY becomes even more important, not only to communications, but to the whole C³I process.

The subordinate elements which support the principle of HOMOGENEITY of communications are modular commonality, network synthesis and integration.

* * * * *

Modular commonality is the physical and electronic standardization of component parts of joint service communications means, such that they can be temporarily or permanently combined with other such assemblies without loss of interoperability. Such commonality can be achieved only through common design. Every effort should be made to ensure minimum size and weight and simplicity of operations without loss of interoperable performance, flexibility, or reliability.

Commonality minimizes problems of operator training and familiarization, communication procedures, supply of equipments, and maintenance. Flexibility is ensured by mechanical interchangeability and common mechanical and electrical interfaces.

Components should be easily changed, faults capable of being diagnosed down to the sub-unit level, and minimum amounts of spares carried. Ancillary supporting equipment should also be standardized. The communications means should be capable of efficient operations after only a brief period of instruction, so that it can be used by relatively unskilled personnel. It should be capable of efficient operation in the expected battlefield environments, in high ambient noise levels and while stationary or on the move.

In sum, the qualitative criteria for modular commonality are 1) the extent of inter- and intra-service communications interoperability, 2) the degree of standardization of the component parts among the services, 3) the flexibility provided the commander to tailor his communication requirements to fit the situation, and 4) the ease with which non-technical personnel can reconfigure or repair the communication means.

So characterized, this subordinate element of homogeneity of communications promotes inter- and intra-service cooperation, reduces and simplifies logistics, is adaptable to NATO standardization agreements for coalition interoperability, and provides the commander with a significant reconstitution/reorganization capability. It is also the means by which to develop a universal compatibility among source C³I terminals and communication networks.

Perfect commonality may be difficult to achieve, but the degree to which modular commonality is achieved will have a direct effect on the introduction of improved equipment into the force. The lack of upward and downward compatibility requires force package fielding of

improved capabilities in unit sets for all units required to communicate with each other. The risk here is the difficulty of determining in advance who will need the new capability and, in the event of combat loss and/or the introduction of new units into the area of operation, the likelihood of communications incompatibility. The more the modular commonality, the less likely these problems.

* * * * *

Network synthesis is the ability of communications to provide automatic passive and active connectivity to all terrestrial and non-terrestrial means for all required users, regardless of whether they are mobile or stationary. This enables any user, regardless of how or by what mode he is connected into the communications system to achieve immediate and automatic connectivity with any other user. This is accomplished without the caller needing to be aware of the other party's physical location and without any constraint resulting from distance or mode of communication, provided that at least one available route exists between both. This ensures two-way, multi-mode, multi-means C³I information transfer among higher, lower, and lateral headquarters, and among supporting air, land, sea, space and allied elements.

Network synthesis and modular commonality coupled with the concept of indeterminacy points toward multiply connected, integrated command, control and intelligence systems with built in automated communications-functional user interfaces. As users of the

communication means move, the system must be capable of expansion and contraction automatically. It must accommodate the fluid and dynamic battlefield described in Chapter II in which offense and defense will be taking place simultaneously over a broad area. The resulting user movement must be accompanied by automatic information connectivity to all other users to ensure C³I continuity, survivability, redundancy, flexibility and efficiency.

Just as important as the inter-relationship of communications means and battlefield command, control, intelligence, weapons, and sustainment systems is the redundant layering of communications means, to include immediate access to non-terrestrial means. The use of satellite communications must be an integral component of network synthesis. The contribution of satellite communications to achieving depth, agility and synchronization deserves special consideration. Satellite capability is a direct combat multiplier which enables an "all informed" distribution of information on a fluid, non-linear, battlefield. Satellites enhance continuity of communication through redundancy with terrestrial means, permit the coordination and synchronization of widely separated activities, help link joint and allied capabilities, and assist in providing timely intelligence from national sources to US forces operating independently or under allied commands.

Synthesis of a combination of communications means into an composite system with automatic access helps compensate for individual component deficiencies. The additional qualitative criteria for network synthesis are 1) rapid, automatic access by the

commander to all available communications means, and 2) assurance that these means do not become, individually or collectively, the center of gravity of the force. Network synthesis also promotes decentralized command and control and permits the commander to perform his command and control functions from wherever he feels he needs to be to influence the operation. His subordinate and supporting units and staff functions should have the same inherent flexibility.

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The final subordinate element of the principle of HOMOGENEITY is Integration. For our purposes, integration is the automatic interconnection of user source terminals with the communications system. Currently there are no military functional systems that are completely integrated either with other functional systems or with the communications upon which they all depend. Most systems achieve only a degree of integration.

In the design and development of integrated C³I, ingenuity and automation offer large rewards in assisting field commanders to employ and control their resources effectively and responsively. Originally automation was used only to replace manual control of specific individual weapons or support systems with little regard for how command and control should function in the anticipated battle environment. Now and in the future, we must think in terms of how we plan to fight in terms of a total systems concept. We must analyze

the critical needs of commanders and their staffs as well as weapons and support systems in acquiring and synthesizing combat information, and taking advantage of that information to maximize relative combat power. Sub-systems must then be designed and developed to facilitate decentralized combat execution, and to interface automatically with other functional sub-systems. Together, these sub-systems must then be united to form a totally integrated, on-line, real-time, fault tolerant C³I system. The commander and his staff, as well as those responsible for the execution of specific functions, must have easy access to the information they require to make decisions. They must also receive automatic feedback that the decisions disseminated were received by the intended recipient.

An example of what is desired by integrated C³I is the concept of a future command post vehicle. The equipment contained within this vehicle must sustain communications both while on the move and while stationary and simultaneously, enable the commander (or individual staff elements or officers) to perform their functional duties. Operational delays associated with the establishment of communications are eliminated by freeing CP's from fixed communication nodes. Information acquisition, processing, and transfer is a continual process not inhibited by maneuver or location on the battlefield because access to the communication system is automatic. The command post contains its own internal power source, is environmentally self-contained, configured for both wheeled and tracked vehicles and, through homogeneity of equipment, can be readily re-configured and repaired. Staff operations can be

dispersed for survivability without penalty to the exchange of required information (whether such dispersal is a sound way of doing business is another matter).

In sum the qualitative criteria for integration of C³I are 1) the degree to which communications interface automatically with C³I subsystems, and 2) the degree to which the latter can be united into a single efficient, reliable, composite capability that the commander and his staff can exploit easily to effect coordination and decisively employ available resources.

CHAPTER V

PRINCIPLE OF VERSATILITY

The third operational principle of communications for C³I is the principle of "VERSATILITY". Versatility is the ability of communications to adapt readily to unforeseen C³I requirements. This must be achieved without restricting the agility of the commander's forces or his exercise of initiative and synchronization. The conduct of operational and tactical level warfare envisioned by FM 100-5 requires flexible formations, innovative tactics and leaders at all levels who are capable of exercising intelligent initiative in harmony with the senior commander's intent. To accomplish this, commanders and their staffs require versatile communications which can adjust to their changing needs. This becomes even more important with the increase in scale and tempo of modern combat operations and with the increased complexity of joint and coalition warfare. This requires communications to be flexible, mobile, and adaptive.

"In 1931 the first demonstration ever of a tank formation being controlled on the move from a single master control was made in England. If the Germans were further behind at the time, they were, however, more seriously committed to the acquisition of comprehensive tank radio networks--largely because of Guderian's insistence. His experience in 1914 left him in no doubt that if highly fluid long-range operations were to be conducted with coordinated zeal, radio communication had to be accurate, concise, and widespread from the pinnacles of command down to the lowest possible level."¹²

"The early use of the wireless for command in battle to the single tank was due to Guderian's insistence. . . He had an eye for the essential and at the same time. . . was also able to judge when to press for his goal--which is a vital

characteristic. Few people know how to recognize the moment. Comparatively speaking, as much effort was put into the development of communications as into the fighting vehicles themselves. . . .¹³ "The panzer divisions created by Germans were not all tanks, each consisting of a motorized infantry brigade in addition to an armored brigade. In fact, the great majority of the field army was infantry. Surprise was the heart of German tactics; mobility and maneuver were the means used to effect it in time and space."¹⁴

"The subtle tactical handling of units and formation which, at the beginning of each campaign, were so often outnumbered, and frequently produced by surprise that overwhelming concentration of strength at the crucial point, puts Guderian on a par with the Great Captains. Though the original strategic plan to breakthrough the Ardennes into northern France in 1940 belongs to Manstein, it was Guderian who reinforced the High Command's nerve by confidently pronouncing the feasibility of infiltrating massed mechanized armies through intricate terrain (a genuinely original concept in its day) and he whose pre-war preparations engineered the techniques that made the movement possible not only by his own corps but by that of every other part of the German Army. For he developed the unique logistics and communications systems which enabled mechanized troops to operate independently. . . and to respond rapidly and flexibly to the commands of its leaders. Without this system in perfect operation nothing would have prevailed."¹⁵

For the Allies in World War II, the emergence of a third combat force, air power, with which the Navy and Army had to operate closely, but which could also act independently, complicated joint command. While improvements in communications permitted the conduct of war over great distances and by great coalitions, the result was added complexity.

Operations in the China Burma India (CBI) Theater in 1944 demonstrate this change. Communications for the Chinese troops fighting in northern Burma against the Japanese were provided by General Stilwell's Northern Combat Area Command (NCAC). This command provided communications between the NCAC headquarters and five divisions, as well as among intelligence and tank groups. Included in the five divisions were three Chinese divisions: the 22nd, 38th, and 50th Divisions. "They also provided communications with the British Fourteenth Army, the Fort Hertz group, the Y-Forces on the Salween River and the headquarters in Chungking to the east and in New Dehli to the west. The environment in which the communications operated was abnormal--unlike that experienced anywhere else except in the tropical islands of the Pacific."¹⁶

Environmental conditions of "low ground conductivity, the masking effect of heavy vegetation, high mountain ridges and long distances adversely affected communication propagation, not to mention the effect of dank heat and fungus growth on the equipment itself."¹⁷

Under these difficult conditions, standard-issue and Lend-Lease equipment was configured, re-configured, and improvised in every possible way to establish and maintain command and control. This included the substitution of different equipment in aircraft to communicate with tanks on the ground and for directing artillery fire.

The configurations eventually settled on were also "used both in ground combat and in communications with aircraft by the Galahad Force--the 5307th Composite Unit (Provisional), or Merrill's Marauders--whose direction had to depend entirely on radio."¹⁸

"Radio communications were of course absolutely necessary for the control and integration of a campaign in roadless jungles. Jungle warfare, almost more than any other sort of combat, compels the highest degree of independence on radio. And, ironically, the environment presents conditions that are the most hostile to facile communications. Not only advance troop movements had to be coordinated by radio. Every man in such formations as the 5307th Composite Unit had to depend entirely upon air support for all his supplies-for every last item of food, ammunition and medicine. Replacements could come only by air, and only air could remove the wounded and desperately ill to base hospitals over the mountains in India. The all-essential communications that could call for air support, and that guided the aircraft to the exact drop site, had to depend upon radio."¹⁹

Because of shortages in communications equipment, the need to improvise, the unforeseen effects of hostile environmental conditions, the diversity and dispersion of forces, and the total dependence on communications for coordination and support at both the tactical and operational levels, there were inevitable criticisms of communication failures.

However, "it is notable that the decisive element in the Allied recovery of Burma in 1944 was not overlooked by the Japanese. For in addition to granting that superior American air power and air support of ground troops were decisive in that struggle, the enemy acknowledged further that superior communications had made possible, in turn, the air support."²⁰

In the European Theater of Operations, US Forces were also improvising communications equipment, techniques and procedures to develop better air-ground coordination. Unlike the German Forces in which the army was the central service and the air force (Luftwaffe) served as mobile artillery support, Allied forces had to accommodate

the independent development, mission, and doctrine of the Army Air Force. Common purpose, versatility of communications and initiative by commanders all significantly contributed to making this accommodation. In Italy, U.S Army and U.S. Army Air Force (AAF) headquarters were frequently collocated and ground commanders were allowed to talk to pilots over air liaison communications. After the Normandy landings, Major General Quesada, the Commander, IX Tactical Air Command, put 1,000 pound bombs and rockets on Thunderbolt airplanes and persuaded General Bradley to give him Sherman tanks so that he could install AAF high frequency radios in these tanks to permit his air support parties (i.e., air liaison officers) to ride at the front of tank columns. By the beginning of Operation Cobra in July 1944, there were twelve of Quesada's fighter-bomber groups operating from bases in France. Typically, four P-47 Thunderbolts covered an advancing column of armor, provided armed reconnaissance and attacking targets in front of the column. The ground combat commander was able to monitor AAF communications, receive information from the air cover, and request, directly to the pilots, that the flight attack targets that threatened the ground advance. The versatility of communications and the initiative of dedicated professionals provided Bradley's exploiting columns an accompanying reconnaissance and artillery force skillfully adapted to enhance the ground forces' mobility.²¹

The war in the Pacific was significantly different from that in European Theater of Operation, and more remote, more diverse and vastly greater in scale than the CBI theater. Once again,

versatility of communications played an important role. The Pacific campaign was a series of hops from island to island, bypassing strong points which were later isolated by sea power. Amphibious operations by Army and Marines were undertaken at much greater distances from bases of support, were directed against targets of limited depth, and were supported by guns from the fleet and by airpower from the Navy, Marine, and Army Air Force.

"Army communications supported airfields, their communication and navigational needs and operated the Aircraft Warning Service used by aircraft of all three services. At all the larger Southern Pacific bases operating circumstances inevitably compelled joint cooperation and use of mutual Army-Navy communications facilities. The theory that integrated communications best serve the interest of unity of command became a workable reality. The same equipment, the same circuits, the same codes and ciphers, the same message procedures and the same operators served all units-Army, Army Air Force, Navy and Marines-on the island."22

As the above historical examples have shown, communications should not and cannot exist for its own sake. It exists only for the purpose of facilitating command and control through correct situation assessment and the projection of the commander's will in the form of relative combat power to achieve military objectives. Only the versatility of communications made possible the tying together the independent, but mutually supporting, joint and combined forces. Versatile communications thus contributed significantly to achieving operational objectives, distributing the commander's intent and maintaining unity of effort.

The principle of VERSATILITY of communications supports the tenets of US AirLand Battle doctrine. It supports the tenet of initiative by enabling, through projection of C³I, the proper positioning of forces and application of fire to achieve surprise and to exploit success. This assists in creating a fluid situation in which the commander sets or changes the terms of the battle, achieves rapid and timely concentration, and retains freedom of action. It facilitates the synchronization of joint and combined efforts and helps eliminate confusion and wasteful duplication of effort. Versatility of communications supports the tenet of depth by allowing control over greater distances and reducing the time needed to coordinate and synchronize diverse combat and support forces. It assists rapid concentration of forces to gain relative advantage over the enemy without loss of control over other forces performing economy of force missions. Versatility of communications supports the tenet of agility by providing a means of rapid feedback to the commander and the sharing of information among forces.

Versatility of communications enables the components of the integrated system to fit together in many different ways under different conditions so that what is right today can be right tomorrow.

The subordinate elements which support the principle of VERSATILITY of communications are agility, flexibility, decentralization and autonomy.

* * * * *

Agility of communications is ability of communications to support the maneuver of supported forces. Such agility is achieved through a combination of the mobility of components of the system and their electronic elasticity. In a smaller force, it is not practicable to be strong everywhere across a broad front; the key to defeating a larger enemy force is maneuver, supported by direct and indirect fires. Maneuver is the centerpiece by which to gain positional advantage, achieve surprise, and concentrate decisively to sustain the initiative. Considering the abrupt changes anticipated in contemporary fluid combat situations, the participation and dispersal of joint and combined forces with diverse combat equipment and weapons, and the necessity for rapid movement to gain surprise and concentrate, agility of communications is essential to tactical agility. In addition to being homogeneous, communications equipment and assemblages (to include prime movers and integral power generation equipment) must be sufficiently agile that no special planning or execution requirements are necessary which could lead to command immobility or the inability of the forces to execute the will of the commander.

Electronic C³I elasticity describes the ability of the system to expand, contract, or change electronically as the situation evolves. At the tactical level it permits moving force elements to communicate with adjacent, higher, lower and support elements without the constant movement of the supporting network. Electronic elasticity

is even more important at the operational level because of the greater diversity and dispersal of supported forces. In a fully developed theater such forces will include, in addition to subordinate, lateral, and higher headquarters, command and control of deep operations, operational reserves, logistical support, and interface with theater directed air support and air defense. Synchronization of these forces will depend far more on electronic elasticity than on the physical mobility of communications systems.

Finally, while communications agility cannot and will not produce decisive results by itself, if properly considered in the design of communications, it will make decisive results possible.

The qualitative criteria for agility of communications are:

1) whether it possesses the physical mobility characteristics to accompany forces and headquarters, and 2) whether it is sufficiently elastic to sustain C³I with the required elements without continual physical movement of the entire network.

* * * * *

Flexibility is also an integral subordinate element of the principle of VERSATILITY of communications. While agility of communications expresses the ability of communication system to move and project command and control as fast as the force it supports, flexibility of communications enables prearranged concepts, plans and operations to be altered to meet changing situations and unexpected developments. US doctrine is predicated on the fact that success in

contemporary combat is attained by the combined effects of all combat arms, support forces, and joint services. Only the thorough synchronization of the role, capability, place, time, and significance of each contributing element in sequencing of specific engagements and battles makes the attainment of tactical and operational objectives possible. However, as we have repeatedly suggested, contemporary combat will be dynamic. It is predictable only to the degree that the commander and his staff have correctly assessed the situation, anticipated events, and shaped the battle or engagement to conform to what they want to happen with the resources available. The more effectively the commander anticipates, the more likely he will retain the initiative and the less likely the need to improvise. However, given uncertainty, friction, and chance of combat, some requirement to improvise is inevitable. When conditions change significantly, new decisions must be made to fit the circumstances of new situations. The communications system must be capable of adapting to these new circumstances regardless of the original configuration, so that it is possible rapidly to plan, coordinate, and shift operations to gain or prevent surprise. This makes it possible to conduct sustained operations and to exploit opportunities as they develop.

Implicit in flexibility of communications is the ability to accommodate component change whether through force expansion or change in the character of supported forces. Wars of the future will inevitably be fought by joint forces and, in all probability, by coalition forces. Maintaining connectivity and integration under

such conditions is a complex and dynamic issue; war makes strange bedfellows. Moreover given predicted battlefield fluidity and lethality, reconstitution and reorganization will result in even stranger groupings of forces. Incompatibilities between systems, significant communication interface deficiencies, and non-standard operating procedures and doctrine must be overcome if C³I interoperability is to be sustained on such a battlefield.

The complexity of modern weaponry, associated control systems and the sophistication of information acquisition means have resulted in unpredictable uses and increases in the volume of information flow. This further complicates not only the flexibility of communications but also the effectiveness of coalition interoperability. Communications must be flexible enough to permit modernization without degradation of C³I; however, the modernization of systems have become exceedingly complex. Thus, weaponry, its associated control systems and the intelligence systems must be developed in harmony with the communications through which they managed. In the end, such modernizations must be measured against the sole criterion of how they individually and collectively improve the ability of the tactical and operational commanders to impose their concept of the operation on the situation.

Considering all of the above, the qualitative criterion for flexibility of communications is the ability of the communications system to be easily modified without loss of efficiency. Such modification may be due to changes in internal or external conditions; however, the communication system must continue to

provide the requisite efficient and reliable C³I connectivity for the commander and his staff to fight and sustain the battle. In this regard loss of efficiency must be measured by the extent to which the commander's C³I capability is weakened; whether the C³I systems is unbalanced; and, whether the future flexibility of the system is endangered. These questions must be addressed and reconciled at the service, joint, and combined force levels and produce communications flexible enough to accommodate the answers.

* * * * *

The third subordinate element of the principle of VERSATILITY of communications is decentralization. The requirement for decentralization derives from the geographical separation of forces, the mobility and fluidity of the battlefield, and the lethality of weapons and vulnerability of centralized command and control. Decentralization of communications demands network synthesis. In return, it greatly increases the autonomy of individual commanders in their engagement or battle and reduces the need for centralized staffs.

Impeding decentralization, and an issue which will continue to affect the military services, is the introduction of more and more complex and expensive weapons and support systems. Paradoxically, the nature of these systems and their resultant organizations may lead us down the path they were created to overcome. Together, politics and economics have tended to drive centralization of

authority at higher levels in operations, intelligence and sustainment. At the same time improvements in communications and automatic data processing technology increasingly make such centralization possible. The net result is an almost irreversible trend towards centralizing choice at the higher levels and the associated attraction of commanders and their staffs together where the information converges. This has in turn tied the commander to his staff and distanced him from the battle.

Colonel Richard H. Sinnreich in his paper on "Strategic Implications of Doctrinal Change" commented on a "... command and control system whose centralization gave it great resilience only so long as events were unfolding according to plan . . ."23 This is equally applicable at the operational and tactical levels. The idea of events unfolding according to plan is directly related to the commander's correct knowledge of the situation, ability to anticipate, and ability to coordinate the conduct of and synchronize the desired effects of the engagement or battle. However, friction, fog of war, chance and the nature of future combat itself all reinforce the unpredictable nature of future conflict. Therefore, the obvious need is for creative initiative and agility at all levels in harmony with the senior commander's intent and concept of operations without having to wait for instructions from above.

However, if control is to be decentralized, the location of the commander cannot and should not be constrained by the communications system. Rather, the system should allow him to be where the fate of the engagement or battle is decided. By being able personally to

observe the development of events, the commander is in a position to provide information, ensure the correctness of subordinate actions, respond to problems, render unanticipated assistance through use of available resources to change or modify the situation, exert emotional and psychological influence, and redirect efforts, if required, toward successful accomplishment of the mission.

Obviously, the commander cannot be everywhere and conditions may even prevent him from being where he wants to be; however, no matter where he is, he should be able to sense the battlefield and to have access the progress and results of action, and be able to make and disseminate decisions. Further, his staff must also have the capability to monitor current operations, coordinate activities, synchronize effects, plan subsequent operations in accordance with the commander's intent and, if required, make command decisions in the absence of the Commander. Moreover, if survivability requires staff functions be dispersed, the loss of efficiency of the staff in support of the command should be minimized.

Decentralization of command and control requires uniform access to critical information throughout the battlefield. That access requires reliable and unrestricted exchange of information among local, higher, lower and lateral commanders, forces and staffs. In turn such a reliable and unrestricted exchange requires a dynamic, multiply connected, integrated but decentralized system of communications means.

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Autonomy, another important subordinate element of the principle of VERSATILITY, is also essential to decentralized command and control. It describes the inherent capability of the local commander's C³I capability to perform in a stand-alone mode for effective coordination and command and control. The concept of decentralized command and control implies that authority, responsibility and resources have been delegated to the local commander closest to the battle and that he is responsible for directing actions to achieve the common goal in accordance with a unified plan. He is thus able to act on his own initiative to seize fleeting opportunities when the situation does not allow for consultation with higher headquarters. To achieve this, critical information must be gathered and decisions are made on the scene of action. The local commander's aggregate C³I capability must facilitate this achievement. At the same time, continuity in exchange of critical information must be maintained between senior and subordinate until interrupted; the more complete and timely this exchange, the less damaging an interruption will be.

The qualitative criteria for autonomy are 1) the ability of local C³I capabilities to maintain current information until interrupted, and 2) to function effectively in a stand-alone mode given an interruption of communications with higher headquarters. Autonomy can be enhanced by automation through the concept of local area network capability that can interconnect with the larger C³I systems.

The total or larger C³I system thus consists of interconnected sub-systems; each self-sufficient (i.e., G-1, G-2, G-3, G-4 of a division inter operating with each other and subordinate or lateral forces in either a dispersed or collocated mode but in the absence of communications with corps counterparts).

CHAPTER VI
PRINCIPLE OF SECURITY

The fourth principle of communications for C³I is the principle of "SECURITY." As a principle of war, FM 100-5 states: "Security is essential to the protection and husbanding of combat power. Security results from active and passive measures taken to protect against surprise, observation, detection, interference, espionage, sabotage or annoyance."²⁴ In addition to the above must be explicitly added denying and deceiving the enemy as to friendly AirLand Battle forces' locations and intentions and preventing the enemy from obtaining information from friendly C³I.

The 1914 Russian-German Battle of Tannenberg provides a relevant historical example of the principle of SECURITY of communications. Prior to 1914, France, exhibited a persuasive influence over the other allies--England and Russia. The Czar's generals promised to relieve the pressure on France within eighteen days of mobilization, by advancing against East Prussia with a minimum of 800,000 troops. At the outbreak of the war, however, Russian planners had not contemplated an offensive against both Germany and Austria. The extraordinary influence of France over her ally led to the Russian decision to invade East Prussia as well as Austrian Galicia.

"From the moment the war opened, the French, uncertain that Russia really would or could perform what she had promised, began exhorting their ally to hurry."²⁵ "The First and Second Russian Armies were ordered to be in position to advance on M-14 (August 13), although they would

have to start without their services of supply, which would not be fully concentrated until M-20 (August 19)."²⁶

The invasion of East Prussia began at dawn on August 12. General Rennenkampf commanded the northern or First Russian Army of the invasion while General Samsonov commanded the southern army, the Second Russian Army.

The Russian plan was for the northern army to advance "toward the Insterburg Gap, a distance of 37 miles from the frontier, . . . lying between the fortified area of Konigsberg to the north and the Masurian Lakes to the south. Here the First Army would come through and engage the main German strength until Samsonov's Second Army, turning the lake barrier from the south, would deliver the decisive blow to the German flank and rear."²⁷ "Opposing the Russians, were the German Eight Army, consisting of four and half corps, one cavalry division, garrison troops of Konigsberg and some territorial brigades which were equal in numbers to either one of the two Russian armies. The German orders were to defend East and West Prussia, but not to allow itself to be overwhelmed by superior forces or to be driven into the fortress camp of Konigsberg. If it found itself threatened by greatly superior forces, it was to withdraw behind the Vistula, leaving East Prussia to the enemy."²⁸

From the beginning the German Commander, Lieutenant General von Prittwitz und Gaffron, had difficulty controlling the commander of his 1st Corps. General von Francois' offensive actions threatened to upset the Eighth Army strategy by advancing too far which, in turn, would pull the rest of the Eighth Army after him to protect his flanks. Although General von Francois had initial success in destroying General Rennenkampf's 27th Division, the subsequent attack ordered by General von Prittwitz against Rennenkampf's force was piecemealed. German units had to advance out of prepared positions

on the Angerapp and were dealt a preliminary reverse at Gumbinnen. Although not decisive, it sufficiently alarmed General Prittwitz that he considered a retreat of a hundred miles to the Vistula. His panic resulted in his dismissal and the appointment of Hindenburg and Ludendorff, whose long partnership began auspiciously in this campaign.

Before Hindenburg and Ludendorff arrived at the front, Colonel Max Hoffman, the deputy Chief of Operations for the German Eighth Army, had already worked out many of the details of a proposed counterattack plan which would take advantage of interior lines. "The success of this maneuver depended entirely upon a single condition--that Rennenkampf would not move. Hoffman believed he would remain stationary for another day or more to rest and refit and make good his supply lines."²⁹ His confidence was based simply on the fact that he was able to assure his new superiors that the enemy's uncoded wireless messages could be intercepted without fear that they were a deception. From the beginning, the German commanders had advance information of Russian movements.

Within three days the strategically located railways in East Prussia permitted the secret withdrawal of the German forces facing Rennenkampf for concentration in the south against Samsonov's advancing army, now spread over a front of sixty miles. On August 26, after complete surprise, Samsonov's right wing was routed at Lautern. The next day, far to the south near Usdau, his left wing was entirely cut off from the main body. The Russian center resisted, but Samsonov was ignorant of the forces arrayed against him

and still continued to order forces to attack. By 30 August, his overextended, famished and exhausted column had been nearly surrounded, and it remained only for the Germans to round up their nearly 92,000 Russian prisoners.³⁰

With Samsonov's army destroyed, the Germans hastened to complete their battle on interior lines by turning on Rennenkampf, who had not made a move to aid his colleague. As early as August 29, German troops were detached to the north, and the reinforcements sent by Moltke arrived just in time to take part. On September 5, the first German attacks north of the lakes gained the advantage of surprise against Russian forces, and four days later Rennenkampf ordered a general retreat.

"The German triumph was due to many people and finally, above all, to a factor that never figured in the careful German planning--the Russian wireless. Ludendorff came to depend on the intercepts which his staff regularly collected during the day, decoded or translated and sent to him every night at 11:00 P.M. If by chance they were late, he would worry and appear personally in the signal corps room to inquire what was the matter. Hoffmann acknowledged the intercepts as the real victor of Tannenberg. "We had a ally," he said, "the enemy. We knew all the enemy's plans."³¹

Every commander understands that to exercise command and control he must have effective communications for his C³I process. After the principle of CONTINUITY, the principle of SECURITY of communications becomes the next most important element of command and control. A communications system which lacks adequate security for C³I is not only a disadvantage, but worse, can threaten the very integrity of the force.

The principle of SECURITY supports AirLand Battle tenets of initiative, agility and synchronization. The subordinate elements which support the principle of SECURITY of communications for C³I are indeterminacy, digital transmission, communication security (COMSEC), and stealth.

* * * * *

Security of communications for C³I is significantly enhanced when the opposing force is presented with a picture of battlefield electronic indeterminacy. Battlefield electronic indeterminacy requires the creation of random and redundant nodality throughout the battle area, completely unassociated with any single or multiple sources, or echelons. In this network electronic counter counter measure (ECCM) concept, it should be extremely difficult for the opposing force to develop effective countermeasures without imposing operational or tactical tradeoffs adversely affecting his own C³ systems (electronic fratricide). This concept also provides multiple routes for information acquisition and transfer. The system should be self-organizing with the sources (e.g., users) free to relocate without regard for the location of communications nodes, but able to find multiple access. Transmission characteristics are adjusted automatically for optimum continuity and security. The nodes themselves could be both attended and unattended. The proliferation of attended and unattended communication nodes facilitates network synthesis. Enemy targeting of such a communications system will be

extremely difficult. Enemy targeting of one or more of the communication nodes has an imperceptible effect on the continuity of friendly C³I information flow because of the extensive automatic re-routing capability. Both attended and unattended nodes as well as sources are always in an "on" condition, that is, transmitting continually. The security of the system is its continuous "on" state, regardless whether information is being transferred; this condition deprives the enemy of knowledge of friendly activity, at the same time that the proliferation of emitters deprives him of unit location information. In addition, the permanent "on" state provides instantaneous knowledge of an interruption of a source or a node. When an "off" or no transmission state occurs, it is presumed that there has been an interruption due to system failure or battle damage. The nodes use omni-directional transmissions for versatility and area coverage, while the sources use highly directional transmissions, with the lowest output power necessary to "hand shake" with the nearest nodes. The qualitative criteria for indeterminacy are, 1) a system nodality whose proliferation saturates the battle area preventing association with any unit, function or echelon while at the same time, provides for multiple automatic alternate routing; 2) a continuous "on" state which makes it impossible for the enemy either to identify the emission signature of a user or to determine the content or frequency of information transfer; and 3) an electronically indistinguishable source emission signature.

* * * * *

Digital transmission conveys information in the form of bits (binary digits). A bit is always one of two things (pulse or no pulse, mark or space, 1 or 0, yes or no). By way of contrast, analog transmission conveys information by sinusoidal waves of continuously varying amplitude, frequency or phase, and every minute perturbation of the wave implies a corresponding degradation of the information content. In analog transmission the disturbance, once introduced, cannot be eliminated; the information content is degraded and ultimately the accumulated degradation limits total system performance. In digital transmission however, minor perturbations of the signal do not change the information content. A pulse is still a pulse even if it is perturbed, and only a major perturbation can change a pulse to no pulse or vice versa.

The point therefore is simply this: in digital transmissions the degradation of the received signal by the transmission system does not alter the information content until the degradation is so severe that the receiving equipment reads a pulse as no pulse or vice versa. Because of this fact, digital transmission is not limited by accumulated degradation, and, with digital error detection and correction techniques, the degradation threshold can be significantly raised.

These characteristics also affect the reliability with which information can be retransmitted over long distances by repeaters. A digital repeater reads its input signal, extracts the information and

uses it to generate a new output signal for the next transmission section. Thus, with digital repeaters, there is no limit to the transmission distance which facilitates electronic elasticity. By contrast, analog repeaters are not regenerative and the output signal contains all of the accumulated degradation of the input signal.

Digital systems also have the advantage of greater information transfer capacity at quicker rates, greater security and clarity, greater ease of encryption/decryption, high speed efficient and reliable switching and routing. And because it is independent of the transmission media (e.g., radio frequency, cable, optical, etc) digital transmission readily accommodates improvements in these media.

To exploit the advantages of digital transmission it is necessary to convert primary source information into digital form for transmission and reconvert the digital information to an appropriate useable form at the receiver. Hence, the qualitative criteria for digital transmission are 1) that all future source (e.g., user) systems have the capability to convert information to a digital form, with integral error detection correction techniques, for information transfer, and 2) that communication systems transfer information throughout the tactical and operational levels of battle by digital transmission. Communications should also have the integral capability, at all locations, to interface with available host nation and allied communication means, which, in all probability, may not be digital nor secure. This interface should be available on an as required basis with appropriate indications of the security of the link provided the originating or terminating source terminals.

* * * * *

As the contemporary and future electronic battlefields are proliferated with more and more advanced electronic-based enemy active (mainly jamming) and passive (interception and direction finding) warfare capabilities, Communications Security (COMSEC) must be integrated into the system which it supports, rather than being one of a series of black boxes. COMSEC should be invisible to the user and not introduce technical complexity which limits the flexibility and usefulness of the communication means. To do otherwise will not only inhibit the ability of commanders to exploit the opportunities that their initiative has presented them, but may also subject the C³I system to be quickly attacked by conventional enemy weapons systems. The qualitative criterion for COMSEC of communication means is that information be transmitted in such a manner that it is useless to the enemy in real time and is as difficult as possible for him to understand at some later date. COMSEC equipment and techniques should be consistent with the principles of HOMOGENEITY, VERSATILITY, and SIMPLICITY; provide traffic flow security, node-to-source and trunk security, and special compartmental security as needed, for voice, data, record, graphic and video information transfer; and should also accommodate, automatically, interconnection of the secure and non-secure communications for coalition information exchange.

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A final subordinate element of the principle of SECURITY of communications for C³I is the requirement automatically to employ stealth "type" techniques to eliminate or deceive the enemy as to the visual, aural, photographic, thermal and electronic signatures of communications means. Items to be concealed include, but are not limited to, vehicles, power generation equipment, antenna systems, personnel, unattended nodes, cables, etc. Such concealment preserves the commander's communications combat effectiveness. The qualitative criteria for stealth in SECURITY of communications for C³I are 1) the degree to which the physical properties of communication nodes and source emitters are concealed from hostile detection, and 2) the provision for protection against unacceptable damage or restrictive interruption of the communications mission. Included in this is the requirement for adequate self-defense from air and ground attack in an NBC environment without degradation of communications performance effectiveness.

CHAPTER VII

PRINCIPLE OF SIMPLICITY

The fifth and final principle of communications for C³I is the principle of "SIMPLICITY". Simplicity of communications is the ease with which the commander, his staff and soldiers use it, operators operate it and maintainers maintain it. Paradoxically, in communications, operational simplicity is achieved by technical sophistication. The principle of simplicity of communications facilitates the application of the other operational principles of military communications developed in this paper and, in all probability, is the most difficult to obtain in practice. This is because we do not normally seek simplicity; rather, we look for an effective means for a desired end and merely accommodate complexity in a variety of ways--training, organization, and the application of technology.

Simplicity is an enduring principle of war which has stood the test of time. It has been debated and written about for years. Those years of experience are reflected in FM 100-5, Operations, which states:

"At the operational and tactical levels, simplicity of plans and instructions contributes to successful operations. Direct, simple plans, and clear concise orders are essential to reduce the chance for misunderstanding and confusion. Other factors being equal, a simple plan executed promptly is to be preferred over a complex plan executed later."³²

Here simplicity is concerned with the clarity, directness, and freedom from complications of plans, orders, and the operation itself. History has many military examples of operations which might or might not have been undertaken had the principle of simplicity been rigorously applied as a determinant factor in planning and execution.

"If anyone had insisted on following the rule of simplicity, there probably would have been no airborne operation during World War II. It may be argued that airborne attacks made no decisive contributions to American battle victories. But if they did contribute something to the successes in Sicily, Normandy, Holland or Corregidor, it was not because they offered the simplest of the possible courses of action. On the contrary they were highly complex undertakings."³³

"When General Patton's Third Army was racing across France, pressing hard after retreating Germans, his armored columns soon outstripped the capacity of their supply system, which had to concentrate on bringing up gasoline and ammunition rather than bulky conventional rations. Without the compact rations, Patton's troops never could have sustained the pressure on the retreating Germans. The Nazi Generals had expected to trade space for time, falling back rapidly toward their own borders and prepared defenses, shortening their own supply lines which elongating those of the Allies. The Germans reasoned that their rapid retreat would not only extend the Allied supply lines but also dislocate them and so leave their tactical spearheads vulnerable to Nazi counterthrust. The reasoning of the German Generals was strategically sound, but they were surprised by the ability of the Allies to sustain their attack and deprive the Germans of the breathing spell they expected to gain by rapid retreat. An important contributing factor in this Allied success--the ability to sustain the pressure on the Germans--was the availability of combat rations. Compact, portable, instantly useable without elaborate preparation or cooking, these rations were a triumph of "low" technology. They were vital to the strategic success of Allied arms."³⁴

Although the above are relatively simple examples of the impact of technology on military operations, a more contemporary example can be found in the technological sophistication associated with President Reagan's Strategic Defense Initiative (SDI).

"President Reagan initiated a major effort to explore advanced ballistic missile defense technology in hope that a way could be found by means of active defense to neutralize the threat of nuclear weapons. The Administration's Strategic Defense Initiative (SDI) is controversial because of its apparent faith in the prefectibility of undeveloped defense technology, implied reversal of strategic deterrence, challenges to the ABM Treaty of 1972, and perturbation in U.S.-allied and East-West relation."³⁵ "Space defenses will of necessity be dependent on sophisticated data processing and automated data transmission for battle management, employing radio links that can be severed electronically or disabled by nuclear effects. Considerable technical ingenuity can be applied to strategic suppression by developing the means to attack the most vulnerable modes of any dispersed system. Although it is easy to say automated systems ought to be designed so that they would "fail gracefully," this euphemism may be exceedingly difficult to arrive at practically with the architecture visualized for layered space defense."³⁶ While the future strategic value of SDI technology exploration remains to be determined fully, however, it is quite possible that it will generate various less than perfect, advanced BMD deployment options that then could be put on the shelf in exchange for certain verifiable Soviet agreements. . . ."³⁷

As the above examples have shown, simplicity in the form of increasingly sophisticated systems has had and will continue to have, a profound effect on the shaping of the conduct and efficiency of military operations at all levels of warfighting. Nowhere is this more apparent than in C³I where the soldier, the commander and his staff have become more and more cybernetically connected with

sophisticated equipment. The elaborate and sophisticated electronic, automated, command and control systems must be intelligible to those who use, operate, and maintain them. They must not only be simple to use and maintain, but they must provide the commander and his staff the ability to anticipate and make changes in the probable course of forthcoming combat operations. The application of the principle of simplicity of communications for C³I through optimum available technical performance, supports AirLand Battle tenets of agility, synchronization, and initiative.

The two subordinate elements of the principle of SIMPLICITY of communications for C³I which must be considered are technological sophistication and application of human factors. When reviewing the two subordinate elements of the principle of SIMPLICITY, consider the following: performance requirements normally lead to increased technical sophistication, while consideration of human factors should lead to increased operational simplicity. However, technology sometimes seems to breed its own requirement for sophistication which produce complexity rather than simplicity.

* * * * *

Technological sophistication is the totality of technological means and methods applied to implement the principles of military communications for C³I while ensuring communications are more reliable, more maintainable and easier to operate in combat. Many people often confuse sophistication with complexity, but these terms

are not synonymous. The issue is not technology, but the selective exploitation and application of technology to provide cost effective, reliable, and effective integrated solutions to military C³I problems. The introduction of new systems can, if not intelligently considered, complicate organizations or may develop a cult of loyalists who could override tactical and operational considerations.

"Technological advancement creates a dialectic conflict. On the one hand, those opportunities resulting from incremental change are normally accepted and enthusiastically pushed forward--perhaps too unquestioningly. On the other hand, those technological opportunities offering really significant revolutionary changes (non-traditional) often receive extreme institutional resistance."³⁸

An example is the incremental improvements that have been associated with automating fire support (i.e., TACFIRE) which have tended to centralize this process while at the same time doctrine urges its decentralization. The very nature of the overall systems and organizational structure of TACFIRE may very well lead to the exact situation which the system was designed to eliminate--the lack of effective fire support for extremely mobile combined arms land forces.

For communications, the criteria for technological sophistication are: 1) does it improve the quality, continuity, and performance of the commander's aggregate C³I capability in combat; 2) does it improve the speed of information acquisition, transfer and distribution; 3) does it improve the versatility of the communications equipment; 4) does it improve the homogeneity of communication; and, 5) does it improve and simplify the operation and

maintenance of communications, while also making them soldier proof?
These criteria become especially important to efficient C³I in
joint-service and multi-national formations.

* * * * *

Human Factors. Although the ideal solution is the development of technologically sophisticated communication equipment that are soldier proof, we must remember that war is first and foremost a human clash of wills and that friction, chance, and uncertainty will always be present. Command and control systems and their associated communications must consider human behavior, and provide sufficient latitude for subordinate initiative. The very word "control" denotes a degree of restriction placed on freedom of action. Limits must be sufficiently broad to permit the commander, his staff and subordinates sufficient initiative in mission execution while permitting the senior commander to monitor performance. Further, communications which drive rigid patterns of operations or centralization may be counter productive and extremely vulnerable in a mobile combat environment. Very often if sophistication in C³I equipment, techniques and procedures leads to complexity (the opposite of SIMPLICITY), it is because of the failure adequately to consider people requirements. The human factor, the other subordinate element of the principle of SIMPLICITY of communications, is the capability of communications to operate in the same environment as the soldier and the making of the communications

completely soldier proof--simple to operate and to maintain, not only by the original operators, but also by replacements who will inevitably be less well trained in wartime. In any condition, with the introduction of technologically sophisticated communications for command and control, the role of the human being will in no way be diminished. The latest technical equipment will only provide assistance to the commander and his staff and, therefore, must be simple to use and maintain under extremely difficult combat conditions. However, the users and maintainers must also be able to adapt to the introduction of new equipment. This implies a technical consideration that depends on competence and skill in using the capability and a capacity for improvisation based on actual circumstances. Users and maintainers must, without becoming technologists, be more intelligent, responsible, and more adequately trained than ever before to cope with the unprecedented capabilities available on the battlefield of the future. If the human factor is carefully considered and designed into sophisticated systems, technology can make them easier to operate, maintain, and repair.

The qualitative criteria for application of the human factors in communications for C³I are: 1) reduction of special expertise to operate and maintain the communications, 2) reduction in specialized training required to operate, maintain, and manage the communications, and 3) achievement of safe, reliable, and effective performance by operator and maintenance personnel.

CHAPTER VIII

IMPLICATIONS FOR SYSTEMS DESIGN

Agreement with the principles of military communication for C³I developed in this paper invariably leads to certain implications for communications systems design. As with any doctrine related effort, there will always be imperfections associated with verbalizing theoretical concepts; therefore, to further coherent understanding of the proposed principles and to respond to the critics question- "so what", this chapter will describe, in general terms, a conceptual military communications system for C³I applicable to the tactical and operational levels of war.

Before describing the conceptual military communications system, a word of caution is required. Even if the optimum communications system, based of the proposed principles, were instantaneously available in the field, one should not expect automatic improvement in the C³I capability available to the commander and his staff. This is because communication is but one element in the total C³I information acquisition and transfer process. While the most important, for it must carry out the exchange of information under all combat conditions, communications still plays a relatively minor role in overall command and control. Consequently, changes only in communications will not necessarily lead to a significant increase in effective command and control. As stated earlier, not all available information is either necessary or desired at all battlefield locations and echelons. Commanders and their staffs must be able to

discipline their C³I systems to reduce the amount of information by focusing on those information requirements which are critical to combined arms, joint and coalition success. With communications integrated with disciplined command, control, intelligence and weapon functional systems, information can become knowledge that can be translated into capability for the commander to exploit. The conceptual communications system described in succeeding paragraphs, based on the principles developed in this paper, will facilitate the survivable, timely and reliable information acquisition and transfer to where it can be acted upon by the commander and his staff.

First, in a general sense, all communication transmissions are both digital and secure irrespective of the form (e.g., voice, data, facsimile, video, etc) of the information to be transferred. All communication emitters and receivers are, continuously and simultaneously, in an "on" condition. All emitters transmit continuously at a fixed system rate regardless whether information is also being transferred. Being in an always "on" condition, the system provides instantaneous knowledge of a communications interruption for any reason--equipment failure, battle damage, etc. Further, continuous secure digital transmissions at fixed system rates, regardless of whether information is also transferred, significantly reduces the probability of enemy analysis and/or identification based on the content or frequency of information transfer. The overall communications concept is a loosely coupled, geographically dispersed, distributed information network in which functionally different sources are interconnected in a disciplined

way. While the source systems maybe functionally dissimilar, their identical communications interfaces enable them to be connected to all communication access nodes. These nodes themselves are randomly proliferated throughout the battle area and thus present the enemy with a picture of battlefield electronic indeterminacy.

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User source systems in the above conceptional communications environment should have the following communications characteristics:

- o Automatically self-regulating to achieve nodal connectivity through highly directional antennas with the minimum essential transmission output to "hand-shake" reliably and transfer information with at least two nodes.

- o Automatically self-connecting, whether on the move or stationary, by continually scanning 360° for alternate nodes; seek to always reduce the probability of detection and intercept by selecting those nodes requiring the minimum transmission power to achieve connectivity.

- o Contain integrated power and environmental control systems enabling reliable operations on the move or stationary in NBC, EMP and transient radiation contaminated environments.

- o Equipment is modularly constructed and physically and electronically standardized among the services; it has common multi-purpose hardware and software, and is capable of being expanded and

reconfigured as necessary. Contains automatic fault tolerance, fault detection and self-repairability capability which does not require user assistance.

- o Equipment is user owned, operated, maintained, transported and supplied; capable of operation and maintenance without specialized training and is integrated with the local user functional systems.

- o Provides inherent capability to deceive the enemy as to the visual, aural, photographic, thermal and electronic signatures to an ambient clutter level consistent with the host environment.

- o Is the entry and exit points for information acquisition and transfer in the communications systems without routing knowledge being required of the source terminal user.

- o Information acquisition and transfer is accomplished within a SYSTEM controlled transmission schedule using source terminal buffering established during initial and subsequent "hand shaking". This allows node and source communicating entities to cooperate. Source terminals can also receive queries independent of established schedules based on priority interruptions.

- o Information processing is accomplished at source terminals which are provided with encoding/decoding hardware and name/echelon/titles recognition circuitry. Thus, area access is provided with queuing and priority interrupt storage of incoming and outgoing information accepted by the source terminal. Episodic user inputs are transformed into a synchronous transmission pattern by a concentrator. A concentrator is a programable multiplexer which

provides store and forward operations through a buffer, which itself accumulates information to be transmitted in its allocated schedule at system transmission rates.

- o Contains error detection and correction techniques to ensure that the information received by an acceptor source is as intended by the transmitting source.

- o Information is addressed to the acceptor source by means of the name/echelon/title of the intended receiver and not the location of the acceptor source. Thus source terminals can be allowed to displace at will. Identification of source terminal locations is automatically accomplished as source terminals connect/disconnect from communication access nodes.

- o Information is partitioned within the source terminal into separate elements to speed transmission through the network--each element makes its way to the destination source independently where it may conceivably arrive out of order. It is reassembled into the proper order by the destination source.

- o Each source terminal has identical communication characteristics but can have different internal functional characteristics peculiar to its battle use. However, it must be able to identify the transmitting source terminal, select a destination source, identify a priority of information transfer, order functional information elements, allow the transmitting source to be interrupted based on priority, and identify address association for multiple addressed information and broadcast mode operations.

- o Communications functions while integrated within source terminals, are separated from the source C³I functional computational/information processing functions. This partitionment allows more fault tolerance and reporting of failure or damage to those responsible for operations and maintenance. Local source failures can be reported by the communications portion of the source terminal and vice versa. The source terminals also provide integrators and translators for functionally dissimilar source systems to interface through the communications network for interactive information exchange.

- o Are real time, smart terminals (interactive terminals) that have some degree of programmable information processing capability. They are thus protected against obsolescence since new functions can be implemented by programming.

- o Is capable of "stand alone" operation with other sources in the absence of nodal access; is capable of receiving and retransmitting information to/from vicinity sources without nodal access and achieving Allied communication and information exchange.

- o Has mobility equal to or greater than supported forces.

* * * * *

Supporting the source systems is a battlefield-wide transmission system composed of numerous all-purpose transmission nodes whose proliferation prevents nodal association with any unit, function,

echelon or service while providing multiple information re-routing ability. Nodes of this distributed information communications system should have the following characteristics:

- o Proliferation. The more nodes, the more versatile and less vulnerable the aggregate system.

- o Identical electronic signatures with emitters transmitting omni-directionally for maximum coverage and versatility. Both manned and unmanned nodes also exhibit identical visual, aural, photographic, thermal and electronic signatures consistent with the ambient clutter level of the host environment.

- o Random emplacement in the battle area with a view to uniform saturated coverage. Unmanned nodes are left unattended and periodically checked and repositioned as required. Unmanned nodes may be emplaced and repositioned manually or through air delivery means.

- o Automatically self-connecting to other adjacent nodes in an irregular nodal network structure; the connections are optimized to provide reliable, redundant, multiple alternate routing for access to other nodes and sources.

- o Capable of automatically inter-connecting dissimilar functional source terminals through common communication interfaces and "hand shaking" protocols.

- o Network topology, the pattern of nodal inter-connection in the network, consists of a combination of decentralized node-source loops with associative addressing and high-speed inter-nodal data distribution. Nodes have an address recognition mechanism for the

sources associated with them. Each node picks up the information elements that are addressed for sources at that node and forwards it to the destination source.

- o Nodes have no mass storage capability and only that buffering necessary to utilize the full capacity of the communication circuits. Nodes are densely proliferated so that inter-nodal distances are short permitting high transmission rates. An information flow control strategy is used to ensure the nodes do not become congested, allowing information to remain in the network only as long as necessary to transmit it from originator source to destination source; each node buffers the information until acknowledgement by an adjacent node in the direction of the intended recipient. If no acknowledgement is received, an alternate path is used.

- o Circuits are kept fully loaded even in the absence of maximum information transfer through the use of continuous test messages to check circuit quality. Traffic is queued in source terminals rather than allowed to enter and be queued inside the network; however, priority interrupt functions permit priority information to be transferred as required.

- o Nodes automatically acquire and inter-connect source terminals and update source-node associations for continuous information transfer.

- o The network synthesis of the nodal system automatically integrates satellite paths as logical extensions of the network.

o Nodes are able to provide communications connectivity for information exchange between sources hosted of the same node in the absence inter-nodal connectivity.

o The system is self-regulating and employs adaptive routing in response to change in the number of nodes and sources. Connection flexibility exists through system fault tolerance and the methods by which the system is automatically reconfigured to mask faults in the inter-nodal communication paths and provide adaptive re-routing to other nodes and sources. Interruption of nodes or sources are reported to manned terminals for investigation and action. Nodes have programmable and modular capability to make incremental changes in the system and to provide nodal interface to Allied communication means.

o Nodes provide complete automatic diagnostic capability, integrated power and environmental control systems enabling reliable operation in an NBC, EMP and transient radiation contaminated environment. For manned nodes, design minimizes human fatigue and the number of personnel required.

o Such a system is not a futuristic vision. It is achievable today with on-the-shelf technology. By virtue of its reliability, simplicity of operation, inherent security and survivability, it would go far to easing many of the current problems inhibiting development of an effective C³I system.

* * * * *

Communications more than any other combat related element directly affects the ability of the commander to turn information, ideas and plans into reality. It enables the commanders and their staffs to coordinate (1) the securing of positional advantage, (2) the massing of overwhelming combat effects from diverse and dispersed friendly elements against enemy weakness at the decisive point (3) to repeat their process over and over again throughout the battle area and (4) to, simultaneously and continually, sustain the force. The five operational principles of military communications developed in this paper are intended to stimulate thought and lay a foundation for responsive, reliable, survivable communications which supports and facilitates the execution of US Army AirLand Battle Doctrine. The seriousness of planning and conduct of war requires one to approach it at a level of analysis that enables examination of the essential elements and their interaction. The principles presented are not just conjecture, they are derived from significant historical antecedents, the data of observation and extrapolation of thought on military theory. Their applicability to coalition warfare environment provides principles upon which to build a C³I architecture which will enable the U.S. Army to have the necessary, survivable command and control communications.

As was indicated in Chapter I, the principles developed are not intended to be the final word on the subject. They are intended to provide the starting point, to help develop intuition and insight, to

develop casual order by which to judge the adequacy of potential applications and to stimulate dialogue to develop a consensus of the fundamental principles of military communications for C³I and their qualitative criterion.

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